Susceptibility of Different Potato Cultivars to Purple Top Disease in the Columbia Basin

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Introduction

Columbia Basin potato growers in Washington and Oregon have experienced serious outbreaks of potato purple top disease in recent years. The disease caused significant yield losses and a reduction in tuber quality (Munyaneza 2005, 2006; Munyaneza et al. 2007). It has been determined that the beet leafhopper-transmitted virescence agent (BLTVA) phytoplasma is the causal agent of the disease in the Columbia Basin and that this pathogen is transmitted by the beet leafhopper (Lee et al. 2004; Crosslin et al. 2005; Munyaneza et al. 2006a, 2007, 2008). Despite the increasing importance of the problem, little is known about the impact of this disease on potato, including susceptibility of different potato cultivars to this disease. To gain understanding of the impact of this potato disease in the Columbia Basin, the following research objectives were addressed in 2007: 1) assess the susceptibility of important potato cultivars grown in the Columbia Basin to the BLTVA phytoplasma and purple top disease under field conditions; 2) determine susceptibility of different potato plant growth stages to the phytoplasma under field conditions; and 3) determine BLTVA transmission rate in tubers. In addition, the incidence of BLTVA phytoplasma in beet leafhoppers collected from potatoes and weeds in the vicinity throughout the growing season was determined to estimate when these insects infect potato plants with the purple top pathogen.

Materials and Methods

Potatoes were planted on 10 May 2007 in small plots (4 rows x 50 ft each) at the USDA-ARS Research Farm at Moxee, WA. Potato cultivars planted include Ranger, Russet Burbank, Umatilla, Norkotah, Shepody, Alturas, and chipping varieties FL1867 and FL1879. For each cultivar, there were 3 plots not treated with insecticides and 3 control plots that received insecticide applications to control beet leafhoppers. Plots were sampled weekly for beet leafhoppers, to document the presence/absence of leafhoppers in these experimental plots, and plants were monitored for purple top symptoms. Also, plant tissues were collected and tested for BLTVA using PCR; plants testing positive for BLTVA or free of the phytoplasma were marked, recorded, and hand harvested at the end of the season. To gain understanding of phytoplasma transmission through potato seed, tubers from individual BLTVA free and infected plants were tested for the phytoplasma to estimate the infection rate of tubers. Also, grow-outs of phytoplasma infected tubers were conducted in the greenhouse to assess phytoplasma transmission rate in daughter tubers.

To look at the impact of BLTVA on different plant growth stages, Ranger, Umatilla, Norkotah, and Russet Burbank were each planted on 10 May 2007 in a 300 ft long row. Before plant emergence, each row was covered by a tent-like cage made of insect screen fabric and fiberglass

tree stakes. Different growth stages for each cultivar were exposed to naturally occurring beet leafhoppers by uncovering portions of the cage at desired intervals. Plants were monitored for purple top symptoms and tested for BLTVA by PCR. At harvest, tubers from individual BLTVA free and infected plants were tested for the phytoplasma to estimate the infection rate of tubers depending on the time of infection (exposure).

In addition, during the 2007 growing season, beet leafhoppers were collected weekly from the experimental potato plots and nearby weeds at Moxee and preserved in 70% alcohol. The insects were tested for BLTVA to determine the incidence of the phytoplasma in leafhoppers invading potatoes throughout the growing season.

Results and Discussion

Purple top foliar symptoms were observed in all the tested cultivars, and plant samples collected and tested by PCR confirmed the presence of BLTVA. Purple top disease incidence in plants ranged from 1.5 to 33.5% for the different cultivars in the 2007 trial (Table 1). Incidence of the disease in the plots that received insecticide applications weekly was none or extremely low (0.2 to 0.5%). Our results showed again that most, if not all, of the cultivars grown in the Columbia Basin are susceptible to the purple top phytoplasma (Table 1). Similarly to our previous laboratory and field studies (Munyaneza and Crosslin 2007), Russet Burbank appears to be resistant to or tolerant of the disease, as this cultivar had the lowest disease incidence and plant symptoms were not observed until toward the end of the growing season. Low disease incidence was also observed for the chipping variety FL1867 in both 2006 and 2007 (Table 1).

Table 1. Susceptibility of different potato cultivars to the purple top phytoplasma under field conditions (trials conducted at Moxee, WA, 2006 and 2007).

Cultivar	***BLTVA plant infection (%) in 2006***	***BLTVA plant infection (%) in 2007***
Norkotah Russet	49.3	26.8
Umatilla Russet	26.0	18.0
Ranger Russet	21.0	33.5
Alturas	10.7	16.0
Shepody	10.0	4.0
Russet Burbank	3.0	1.5
FL1867	5.3	3.5
FL1879	12.3	8.5

Hand harvested tubers from individual phytoplasma free and infected plants were tested by PCR to determine how many tubers per plant were infected by the phytoplasma. None of the healthy plants produced BLTVA-infected tubers. In contrast, 24 to 84% of tubers per BLTVA-infected plant harvested from the different cultivars in the 2007 trial were found to be infected with the phytoplasma (Table 2). Similarly to previous observations (Munyaneza and Crosslin 2007), Russet Burbank not only developed purple top symptoms later in the season but also had the lowest infection of tubers. In contrast, other cultivars tested had a high rate of infection in tubers and purple symptoms were visible few weeks after plant emergence. This high rate transmission of BLTVA in tubers is consistent with results of our 2006 field study (Munyaneza and Crosslin 2007). Moreover, grow-outs of BLTVA infected tubers from the 2006 field study resulted in 35% infection rate in daughter tubers. These results are similar to those observed in the grow-out of greenhouse-grown plants in 2005 that showed that also about 35% of infected tubers produced infected plants (Munyaneza et al. 2006b; Munyaneza and Crosslin 2007). These data show that BLTVA is tuber transmitted at a relatively high rate. Additional grow-outs of field tested infected tubers from all different cultivars tested in the 2007 growing season are currently being conducted.

Table 2. BLTVA phytoplasma transmission rate in tubers for different potato cultivars under field conditions (trials conducted at Moxee, WA, 2006 and 2007).

Cultivar	***BLTVA tuber infection (%) in 2006***	***BLTVA tuber infection (%) in 2007***
Norkotah Russet	92	64
Umatilla Russet	80	84
Ranger Russet	60	84
Alturas	88	80
Shepody	64	84
Russet Burbank	25	24
FL1867	88	84
FL1879	96	52

Results of our exposure experiment indicated that younger plants were more susceptible to BLTVA than older ones. Phytoplasma infection was relatively high in potato plants exposed to leafhoppers during the first 5-6 weeks after plant emergence and the infection declined thereafter (Fig. 1). These results are consistent with our previous laboratory and field studies (Munyaneza and Crosslin 2007). BLTVA infection rate in plants was low for Russet Burbank throughout the season compared to other tested cultivars, supporting our previous observations (Fig. 1). Tubers

from BLTVA-infected plants were tested for phytoplasma to assess BLTVA transmission rate in tubers depending on the time of infection (exposure) and the results are presented in Figure 2. Results suggest that there is no correlation between the BLTVA phytoplasma infection rate in tubers per plant and timing of potato plants exposure to leafhoppers (Fig. 2).

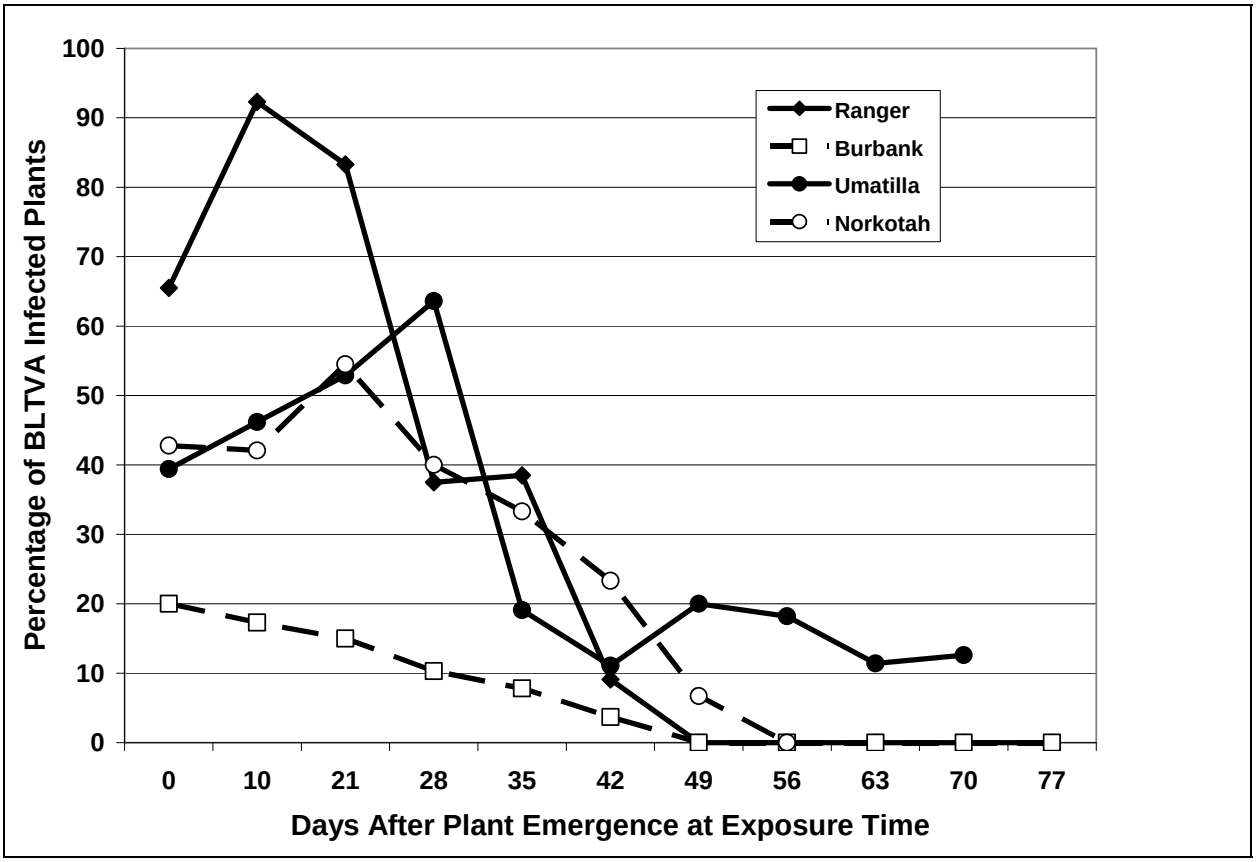

Figure 1. Susceptibility of different plant growth stages to BLTVA phytoplasma. Ranger, Umatilla, Norkotah, and Russet Burbank plants were exposed to naturally BLTVA-infected beet leafhoppers under field conditions. Plants were exposed by removing the row cover (insect screen fabric) at plant emergence and selected intervals thereafter.

In our previous studies, beet leafhoppers were found to be present in the Basin potatoes throughout the season (Munyaneza et al. 2008). Results of our beet leafhopper testing in 2006 indicated that BLTVA incidence in the leafhoppers collected in potatoes and surrounding weeds was relatively high and averaged 36 and 21% in leafhoppers collected from the potatoes and weeds, respectively (Munyaneza and Crosslin 2007). Results from BLTVA testing of beet leafhoppers collected in 2007 showed again that a large number of leafhoppers were infected with the phytoplasma throughout the growing season. Infection in the insects was the highest in August with infection rate reaching 33 and 40% in leafhoppers collected from weeds and potatoes, respectively (Fig. 3). Interestingly, Columbia Basin growers have so far managed to keep the purple top disease under manageable levels by applying insecticides against the beet leafhopper early in the season (Munyaneza et al. 2006b). These observations strongly support the suggestion that older potato plants are less susceptible or more tolerant to BLTVA phytoplasma

or purple top disease. Data from these insect testing studies will provide information on the leafhopper infectivity over a number of growing seasons and will help in the prediction of the severity of the potato purple top in the Basin and proper timing for insecticide applications. This information is also needed to develop action thresholds for purple top disease in the Columbia Basin potatoes.

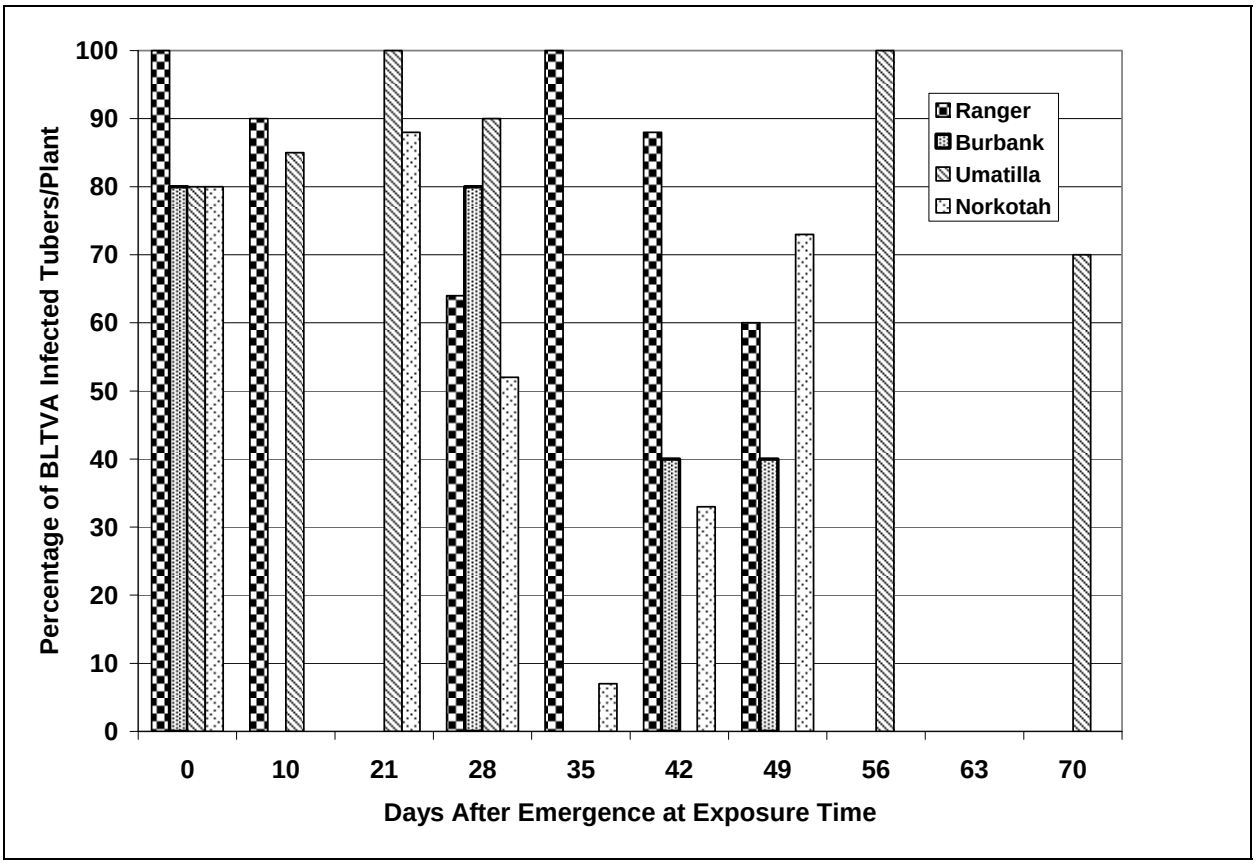

Figure 2. BLTVA phytoplasma incidence in tubers from infected plants depending of the time of potato plant exposure to leafhoppers (Moxee, WA, 2007).

Conclusion

Results from the present study suggest that most, if not all, of the potato cultivars grown in the Columbia Basin are susceptible to the purple top phytoplasma; however, Russet Burbank appears resistant to or tolerant of this plant pathogen or the disease. Younger potato plants seem also more vulnerable to the phytoplasma. BLTVA phytoplasma is effectively transmitted to daughter tubers at a very high rate. Interestingly, Russet Burbank tends to produce fewer infected tubers. Time of BLTVA infection does not seem to affect the number of infected tubers per plant. A high proportion of beet leafhoppers in potatoes and nearby weeds were found to carry the BLTVA phytoplasma throughout the whole season. Information from this study will help growers in the Columbia Basin reduce damages caused by potato purple top disease by effectively monitoring the beet leafhopper and properly timing insecticide applications targeted against this insect pest.

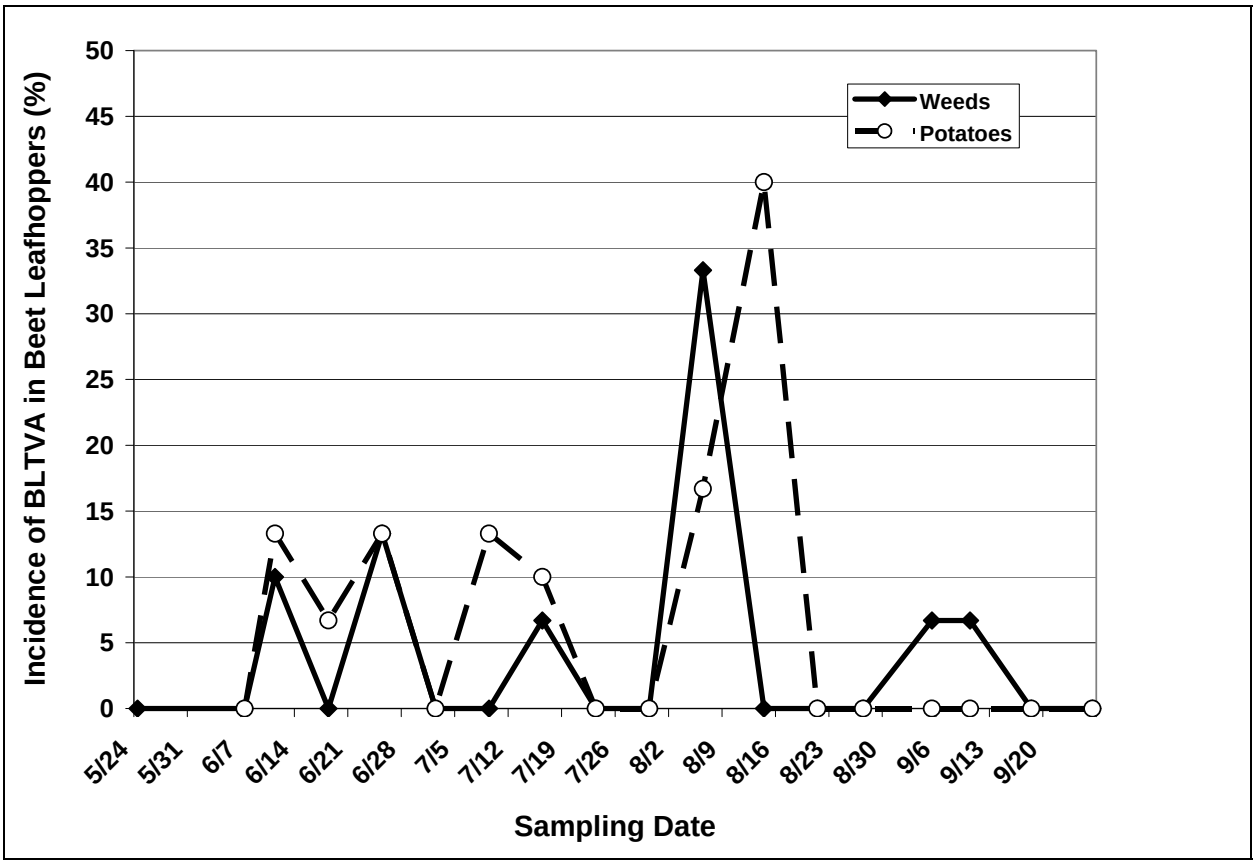

Figure 3. Incidence of BLTVA phytoplasma in beet leafhoppers collected from potatoes and nearby weeds in 2007 at Moxee, WA.

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